

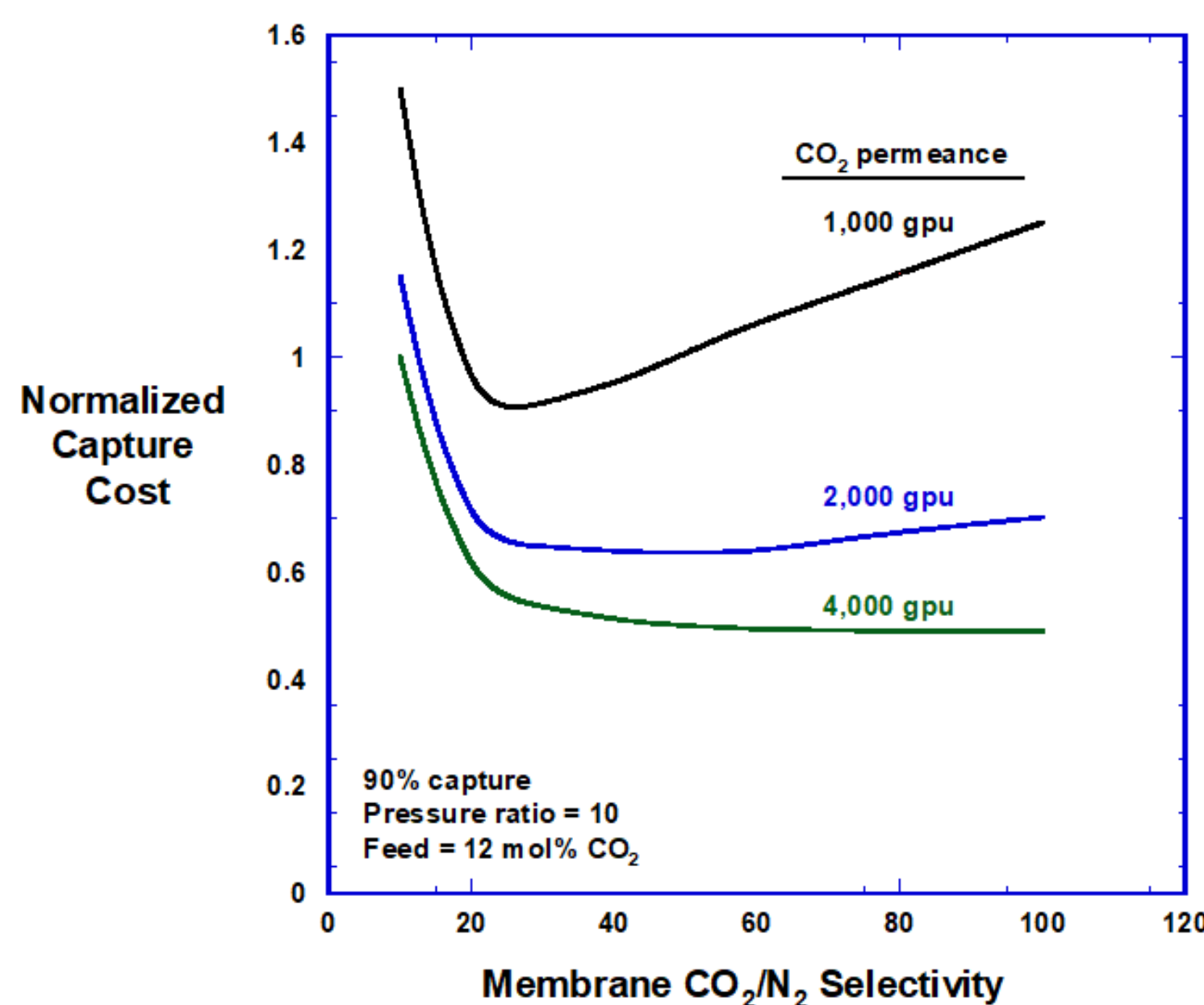
CO₂-philic Block Copolymers with intrinsic Microporosity for Post-combustion CO₂ Capture (SC0020730)

M. Wahl¹, B. Lam¹, J. Maloney¹, R. Prasad¹, N. Esmaili², F. Pazanialenjareghi², G. Zhang², H. Lin², J. Kniep³, J. He³, F. Rivers³, T. Merkel³
¹Helios-NRG, LLC, ²University at Buffalo, State University of New York, ³Membrane Technology & Research

Objectives of DOE STTR Phase 2A Project

- Objective 1:** Optimize TFC membrane for CO₂ permeance $\geq 4,500$ GPU and CO₂/N₂ selectivity ≥ 40
- Objective 2:** Validate stability in long-term tests
- Objective 3:** Scale-up TFC membrane fabrication; fabricate/test bench scale modules
- Objective 4:** Refine TEA

Defining Membrane Properties for CO₂/N₂ Separation



Target: CO₂ permeance of 4,500 GPU and CO₂/N₂ selectivity of 40

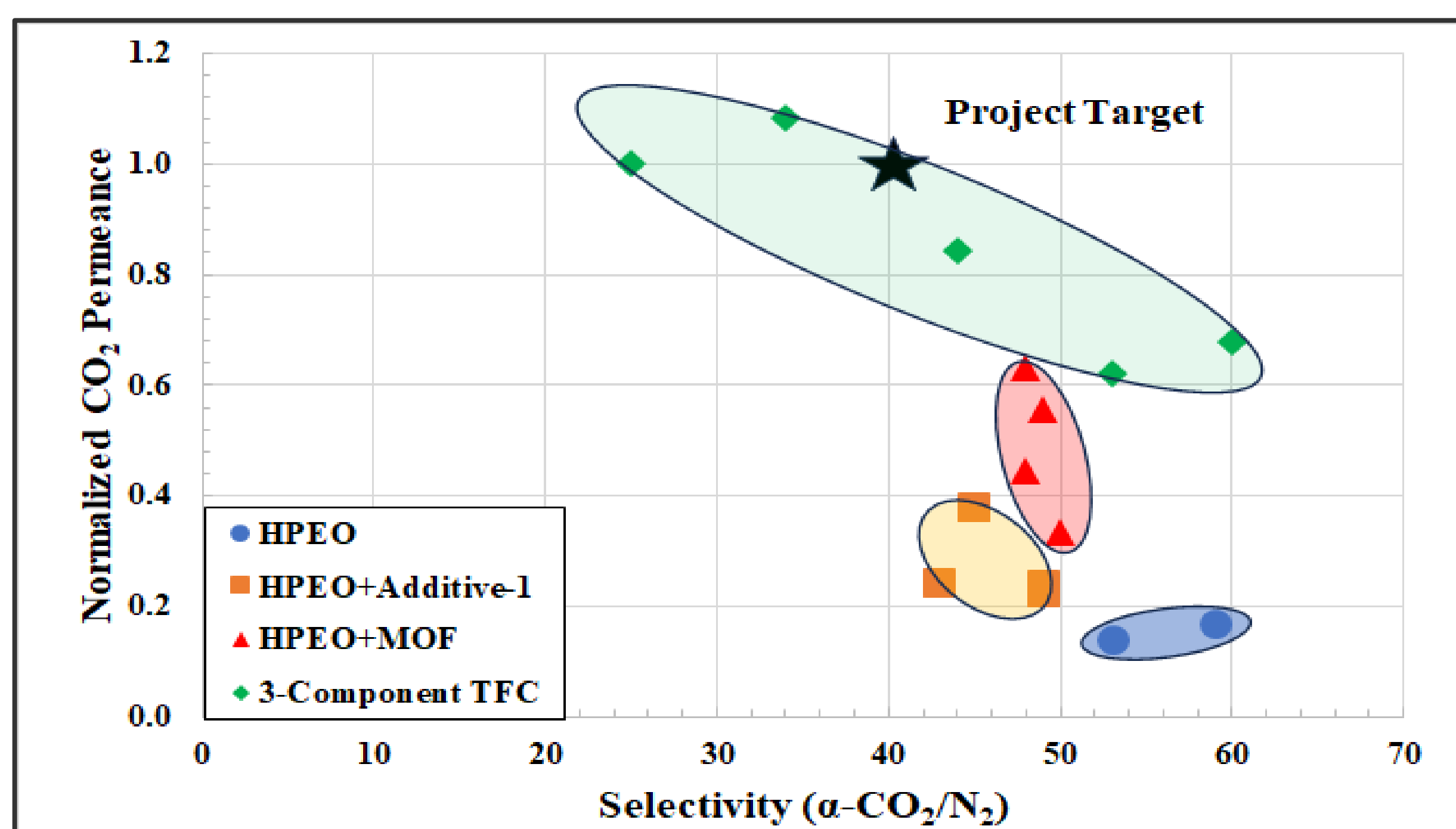
Figure and Calculations by Membrane Technology and Research, Inc., 2024

Our Approach: TFC Membranes Based on Modified Poly(ethylene oxide)

Five steps:

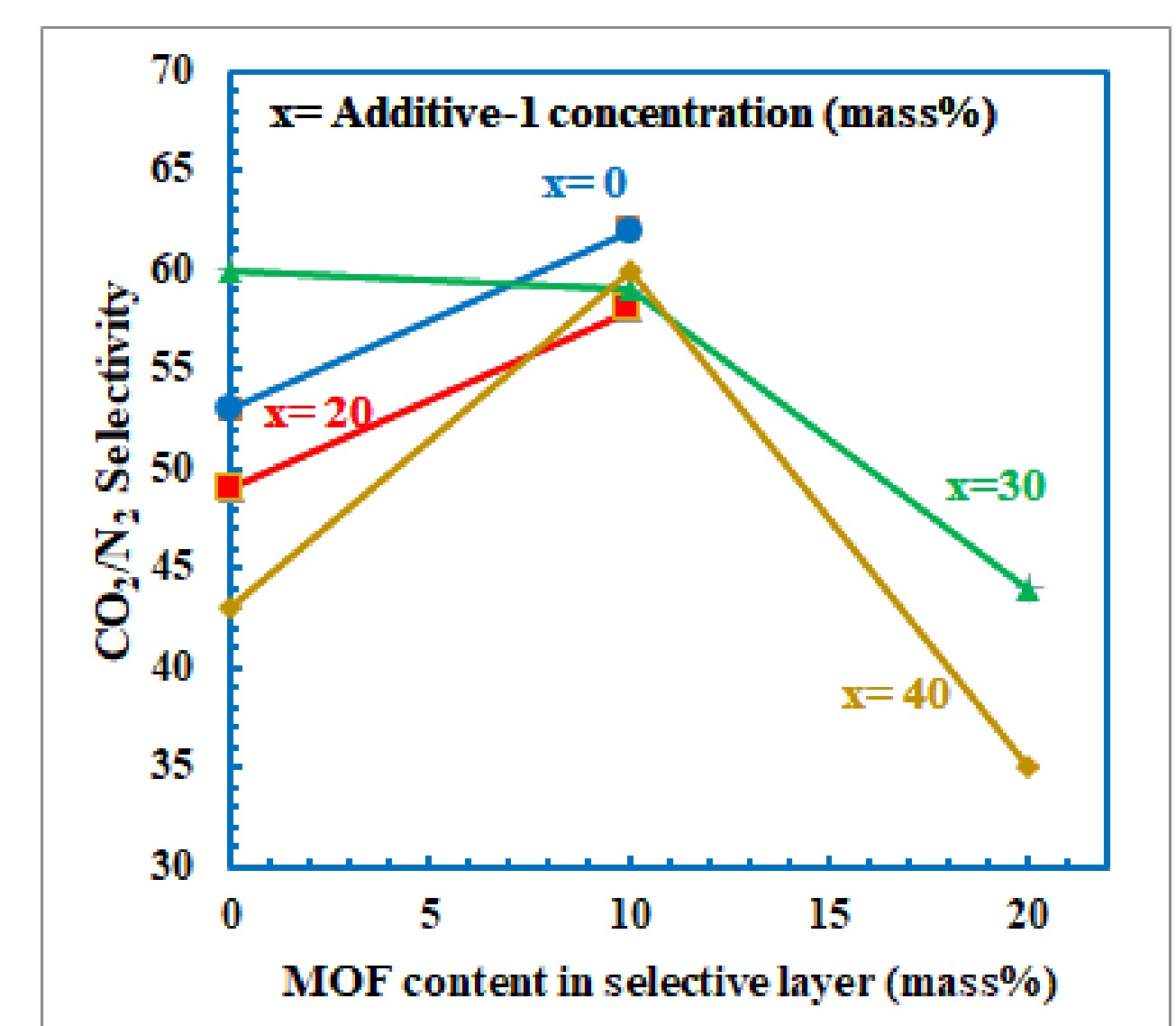
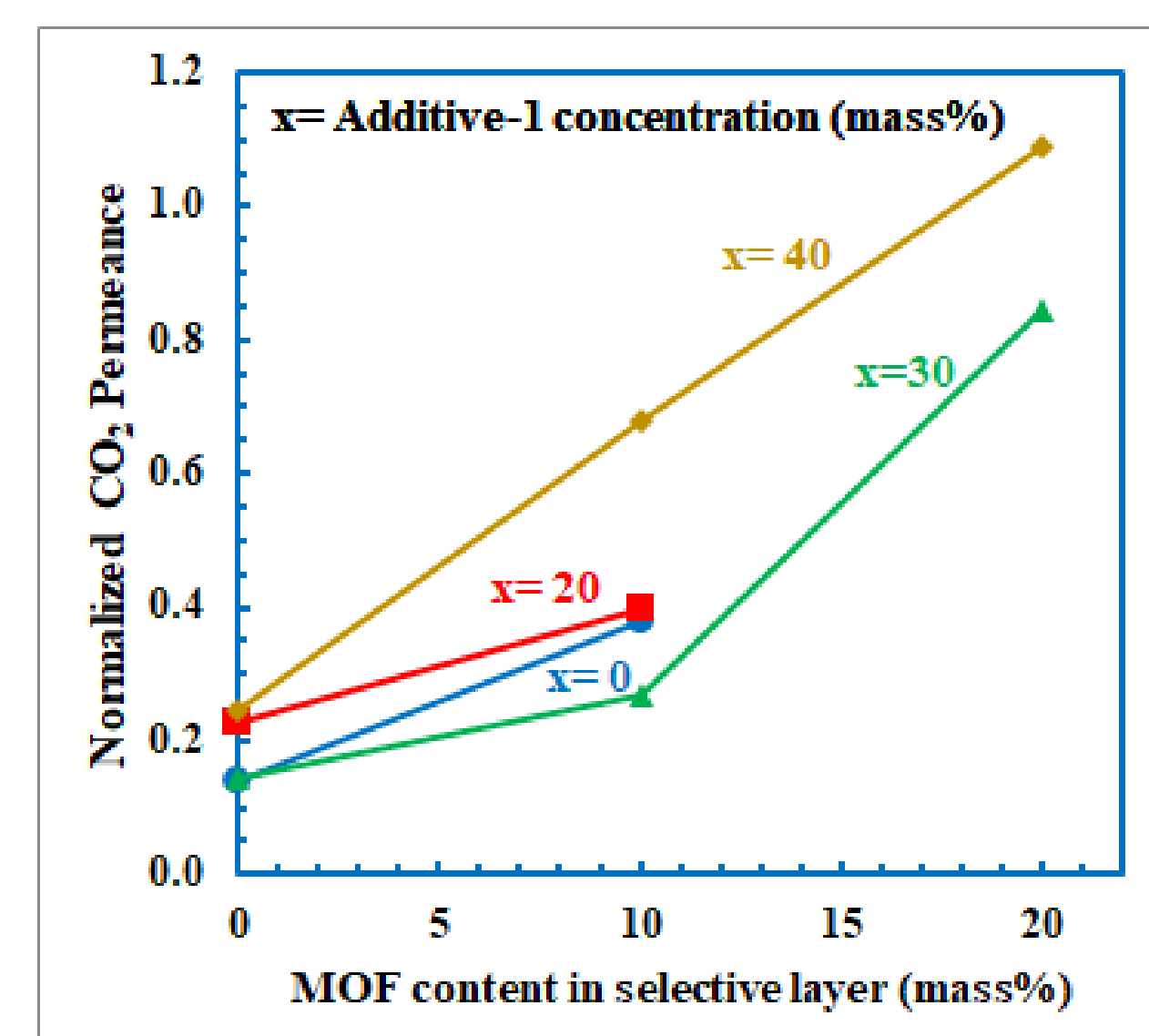
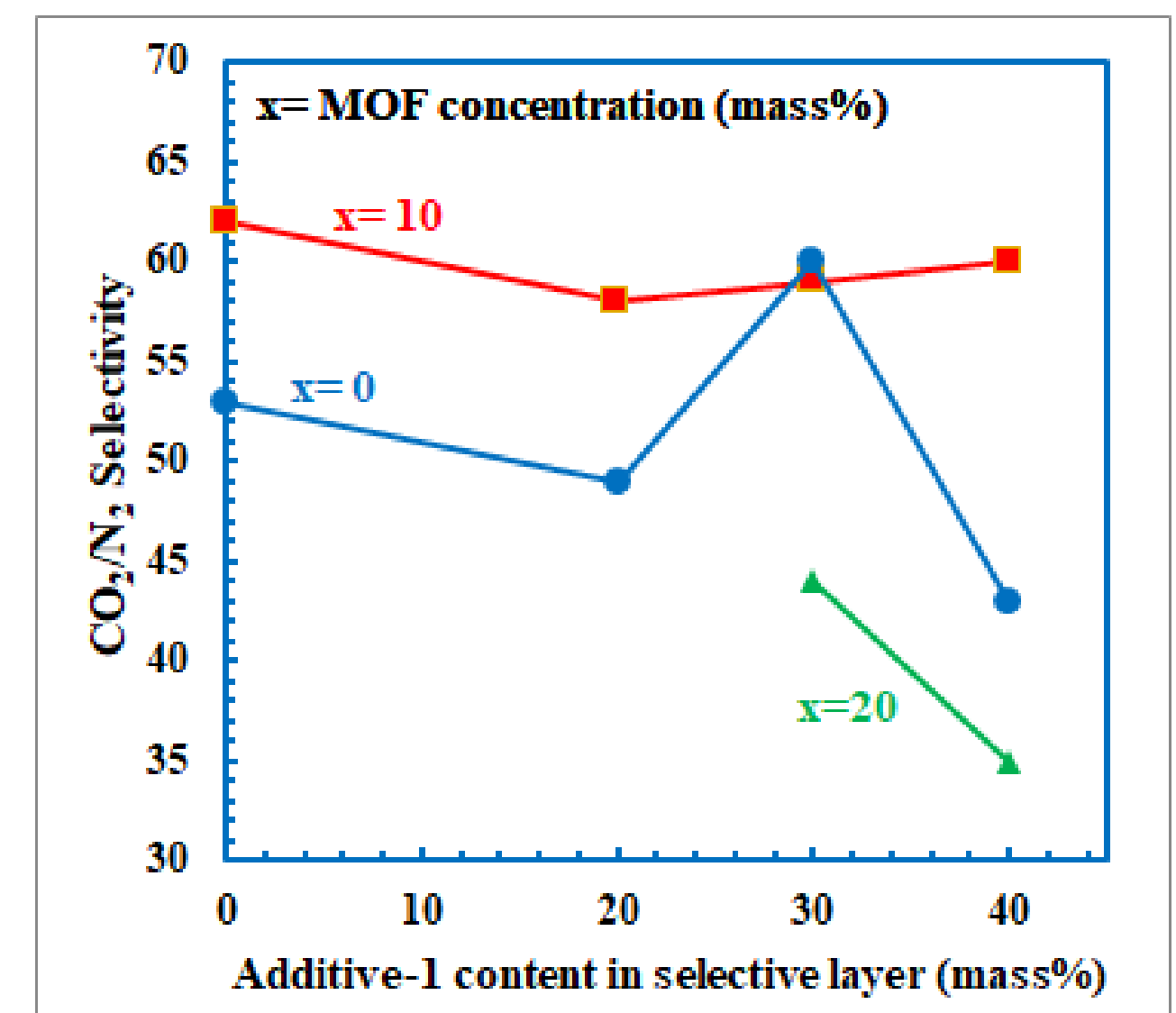
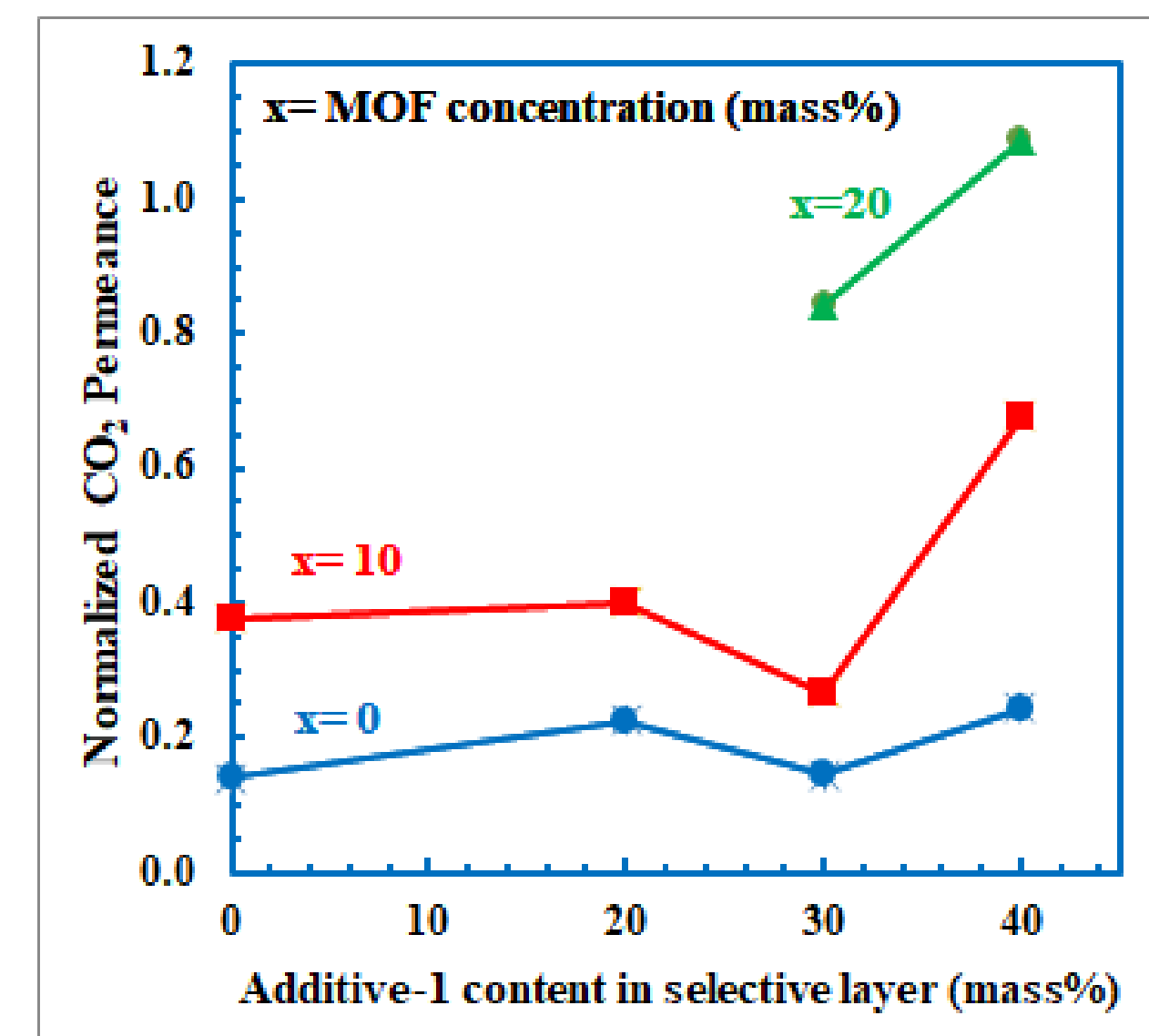
1. Optimize the gutter layer to increase gas permeance of the membrane
2. Synthesize high molecular weight poly(ethylene oxide) (HPEO)
3. Synthesize MOF nanoparticles
4. Incorporate Additive-1 into the selective layer to enhance permeance
5. Add MOF into the selective layer to further increase permeance

Advancement in TFC Membrane Development



Significant progress achieved in advancing TFC membranes towards Project Target

Pure-gas Separation Performance of 3-Component TFC Membranes



CO₂ permeance increases with increasing Additive-1 and MOF concentration in the selective layer at 22 °C

Process Development and Economic Analysis

Metric	Target Properties		Phase 2 Properties	
	4,500 GPU; $\alpha = 40$		3,000 GPU; $\alpha = 40$	
	W/o Cryo	W/- Cryo	W/o Cryo	W/- Cryo
Overall Capture Efficiency	91.5%	91.5%	91.5%	91.5%
Prod CO ₂ Concentration	87.0%	100.0%	87.0%	100.0%
Total Capital (MM \$)	200.4	233	239.8	272.5
CO ₂ Capture Cost (\$/ton)	23.8	33.8	26.7	36.7

- **550MW SC-PC plant**
- **Process:**
 - 2-Stg Cascade + Cryo or MTR 3-Stg + Cryo
 - Capture efficiency: 91.5%
- **Membrane properties:**
 - CO₂ Perm: Target vs Phase 2
 - α -CO₂/N₂: 40-48
 - **64 mil Power; \$50/m²**

